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National Bureau of Standards

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DETROIT

Fatigue Failure of Steel Predicted by New Method

A method for predicting from its stress history how long a metal will last under a vibrating load, or how much load it will stand when subjected to vibration, has been developed by John A. Bennett, of the Bureau's Metallurgy Division. Although this investigation was limited to one metal only, X4130 aircraft steel, the possibility of using the method for predicting fatigue failure of other types of metals is being investigated.

Vibration is a prime consideration in the design of aircraft members, automotive parts, machine elements, and other metallic objects that are subject to its damaging effects.

A metal will often fracture when a pulsating load is applied for long periods, even though the applied stress is much less than that which would cause failure if the load were steady—the phenomenon is known as fatigue.

Fatigue in metals has been extensively studied, and it has been found that for most ferrous metals there exists a stress range within which a pulsating stress will not cause failure, regardless of how many cycles of stress are applied. If this range, which is known as the fatigue limit, is exceeded, a crack will eventually form and will grow until fracture occurs. Prior to the formation of the first crack there is a change taking place in the metal that reduces the fatigue properties, but does not affect the other mechanical properties.

A study of some of the phenomena associated with this damaging process, particularly with a view to making the information more readily applicable in the design of structures, is reported in the Journal of Research for August (RP1733). Fatigue damage to a specimen at a given stress was measured by the decrease of endurance observed at another stress. Two methods are described to determine by extrapolation the point at which cracking starts. A method of expressing damage independent of stress was also developed, which permits the direct addition of damage occurring at different stresses.

Previous studies of fatigue damage have dealt largely with smooth specimens although the majority of fatigue failures in service propagate from points of stress concentration. Therefore, the first part of the work consisted of an investigation of fatigue damage using notched specimens. The results, which were similar to those obtained with smooth specimens, show that the apparent rate of damage is a complicated function of the stress history. Tests to determine the cumulative damage caused by fatigue at more than one stress were also made with smooth specimens.

Reliability of the methods was checked by testing specimens after fatigue, loading at two or more different stresses.

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Laminated Kraft Caseliners Deteriorate Under Mildew Attack

Mildew, known enemy of textiles, leather, and plastics, will also cause deterioration of kraft paper and shipping-case liners with kraft paper as a base, approximately in proportion to the amount of mildew growth, according to a study recently completed by B. W. Scribner and E. Abrams, of the Bureau's Paper Section. Papers reinforced with jute or sisal and sheetings containing cotton deteriorated more rapidly than laminated papers containing no reinforcement. It was found further that mildew growth was heavier on the lines of the reinforcing materials than on other parts of the sheet.

Mildew was one of the largest single sources of damage to supplies for the armed forces in tropical regions. Although less trouble was reported from paper products than from other materials, this study was undertaken as one phase of a broad investigation of mildew damage being conducted at the Bureau. The work was carried out in connection with the development of standards for caseliners, reported in the Technical News Bulletin for July (page 51).

Samples of sheetings used to line shipping cases, kraft papers used in their manufacture, kraft paper coated with asphalt fractions of different softening points, and the seams of liners sealed with various adhesives, were hung in a room maintained under tropical

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conditions. Specimens removed at the end of 3 or 4 successive 4-week periods were examined for amount and species of fungi present and tested for deterioration.

The growth of mildew ranged from slight to heavy on the different specimens. When the data are considered as a whole, the extent of deterioration bore a relation to the amount of mildew growth and the presence or absence of the fungi, *Chaetomium globosum* and *Penicillium sp.*

The caselining materials, the base papers, and kraft paper coated with asphalt all decreased in strength, stretch, and water resistance but some were more resistant than others. Of 18 unreinforced kraft laminated papers, 8 showed no deterioration at the end of 4 weeks' exposure, 3 at the end of 8 weeks, and one at the end of 12 weeks. By the end of 16 weeks all showed evidences of deterioration. Papers reinforced with strands of sisal fibers or jute scrim cloth deteriorated much more rapidly than the other laminated papers, and the growth of mildew was heavier on the lines of the reinforcing material than on the other part of the sheet. Sheetings with cotton wadding or cotton cloth as a component also deteriorated much more rapidly than the kraft laminated papers containing no reinforcing material.

The deterioration of the base papers in general was more rapid than that of the asphalt-laminated kraft papers containing no reinforcing material.

The rate of deterioration of the kraft papers coated with asphalt was rapid and the higher the melting point of the asphalt fraction, the greater was the deterioration. In general, the mildew growth was heavier on the uncoated side than on the asphalted side of the sheets. In tests made with pure cultures of fungi, the growth of mildew was very heavy on the kraft paper and very light on the different asphalt fractions, and the amount of mildew growth increased with increase in the softening points of the asphalt fractions.

None of the adhesives showed significant failures after the exposures, when the seams were either dry or wet. The adhesives were composed of mixtures of asphalt, rubber, and synthetic resins.

Hand Papermaking in Japan

The Japanese still make appreciable amounts of quality papers by hand processes that have changed little for a thousand years. C. G. Weber, in a recent technical survey of papermaking in Japan, found the manufacture of handmade papers there of interest to the modern technician. The leisurely, primitive methods have no place in our own highly mechanized paper industry. However, unique results are obtained by painstaking craftsmanship, and a variety of papers possessing unusual strength and beauty are produced.

Fibers for these papers are derived from the barks of three native shrubs which are cultivated after the old method of growing willow shoots for baskets in certain sections of this country. The barks are stripped from the shrubs, and the fibers derived from them by the most painstaking hand operations. The paper is then formed without the aid of machinery. It has been estimated that one Japanese papermaker can make about as much paper in 1 year as a relatively modern machine will turn out in about 20 minutes. Nevertheless, the handmade industry survives in Japan and is the basis for interesting commodity enterprise there. Many papermaking communities are scattered throughout Japan proper, mainly in the hills and usually accessible only with difficulty. Some districts contain a dozen papermaking houses, others more than a thousand. The setting is usually picturesque and the industry savors of the ancient civilization of the Orient.

A report of the survey has been published in the June 1946 issue of The Paper Industry and Paper World. The various papermaking processes are illustrated with photographs and with drawings by Japanese artists.

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U. S. DEPARTMENT OF COMMERCE
Henry A. Wallace, *Secretary*

NATIONAL BUREAU OF STANDARDS
E. U. Condon, *Director*

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Case School of Applied Science Awards Honorary Degree to Eugene C. Crittenden

Eugene C. Crittenden, Associate Director of the Bureau, and for 25 years Chief of the Division of Electricity, was awarded the degree of doctor of science by the Case School of Applied Science on June 16. In view of international recognition of his contributions in the field of measurement, particularly illumination, the citation read in part, "A devoted servant of the public, exponent of precise measurement, and international authority on the standards of science and industry."

Within a few days after receiving the degree, Dr. Crittenden sailed for Europe, where in London and Paris he took part in meetings and discussions looking to the reestablishment of international relationships in science and technology. The meetings included those of committees of the United Nations Standards Coordinating Committee and the International Electrotechnical Commission. He is president of the United States National Committee of this latter commission and has served in a similar position with the International Commission on Illumination.

Dr. Crittenden also visited the British National Physical Laboratory and the International Bureau of Weights and Measures at Sevres.

The preliminary discussions at this time will, it is believed, pave the way for vigorous renewal of activity in international science.

Variations in Sporadic-*E* Ionization Observed at Washington, D. C.

Another phenomenon of the ionosphere, in addition to the regular ionospheric layers, of great importance in radio transmission is the so-called sporadic-*E* ionization. Investigations at the Bureau indicate that this irregular ionization occurs about 60 miles above the earth's surface, and appears in large and small clouds, which may come and go in a few minutes or be entirely absent on some days of the month. On a statistical basis, however, sporadic-*E* exhibits some regular trends insofar as variation with the time of day, latitude, and month are concerned, as well as the number and latitude of sunspots.

Knowledge of the incidence of sporadic-*E* is of value because pronounced ionization of this type assists high-frequency radio propagation. The phenomenon is particularly important in auroral regions where ionospheric disturbances are frequent. At the same time sufficient sporadic-*E* ionization may cause unwanted propagation of high or very high frequencies over long distances. For example, interference at very long distances between services usually having only local coverage, such as FM broadcasting, results, at least in part, from extended propagation provided by this ionization.

Variations of sporadic-*E* ionization observed at Washington, D. C., were investigated with respect to diurnal, seasonal, and both long-period and short-period solar-activity variations, as well as variation, with frequency, of *fEs* (highest frequencies on which sporadic-*E* reflections are observed) above a given frequency. The results of these studies at the Bureau were presented by Marcella Lindeman Phillips before the American Geophysical Union on May 28.

Maximum values of sporadic-*E* ionization were observed during periods of minimum solar activity, with marked rise in the percentage of time of occurrence of average nighttime *fEs* in excess of 3 Mc (7 percent per degree of heliographic latitude) with decreasing average heliographic sunspot latitude below 11.6°. Maxima in this quantity occur during both solstices, that during summer solstice being the greater; minima occur at both equinoxes. The solstice-equinox variation is in fair quantitative agreement with the variation of *fEs* with average heliographic latitude of sunspots for a latitude change equal to the solstice-equinox change in latitude of the center of the solar disc. Both seasonal and long-period solar-activity variations thus indicate that sporadic-*E* ionization may be principally caused by solar corpuscular radiation from regions near the solar equator.

Short-period variations in sporadic-*E* ionization show direct proportionality to solar activity near solstice seasons and slight inverse proportionality during equinox season.

Slight increases in the ratio of monthly to yearly average values of percentage of time of occurrence of *fEs* in excess of 3 Mc for the months of August, October, and November, above those indicated in the regular seasonal variation for other months, may indicate some ionization caused by meteoric bombardment.

The logarithm of percentage of occurrence of *fEs* in excess of a given frequency is inversely proportional to that frequency, this variation with frequency being more pronounced during equinox than during solstice seasons.

Radio Field-Intensity Meter Calibration Service

With the termination of the war, the Bureau resumed its calibration service for radio-wave field-intensity meters. Hitherto, this service was largely limited to the marine and broadcast bands of frequencies, 200 to 1,600 kilocycles per second. With the rapid development of the higher frequency communication, television, and FM bands, the need for standardization of measurements of radio field intensity in these bands has become more urgent.

To meet this need the Bureau's Central Radio Propagation Laboratory carried out a theoretical and experimental investigation on the standard inductive field method of calibrating field-intensity meters. The Bureau is now prepared to make routine calibrations of field-intensity meters having loop antennas over the

frequency range from 100 to 19,000 kilocycles. With the construction of further apparatus the range can be extended up to 50,000 kilocycles, which represents about the upper frequency limit of this particular method.

Considerable work has been completed for extending field-intensity standardization up to 150 megacycles by a standard radiation field method. In this method a known radiation field is set up by means of a standard transmitting antenna in which the current is accurately measured and which transmits over a plain ground of known constants. This method can be checked against the inductive field method in the range from 19,000 to about 50,000 kilocycles. Below 19,000 the inductive field method has been checked against a standard loop antenna used as a receiver in a plane wave field.

The availability of this calibration service should be of aid to those making radio noise measurements as well as to broadcast stations making radiation surveys in order to meet the regulations of the FCC. The work covering the FM and television bands is being expedited in order to meet the needs of these new broadcasting services as soon as possible.

Geometrical Arrangement Increases Accuracy in Measurement of Beta Rays

An improved method for measuring the strength of radioactive materials that reduces the error, in the case of one such substance, radioactive phosphorus, from as high as 300 percent to less than 5 percent, has been developed by L. F. Curtiss and B. W. Brown, of the Bureau's Radioactivity Section.

Radioactive phosphorus, an artificial radioisotope produced by cyclotrons, has been shown to be useful in the treatment of leukemia, a disease of the blood that has resisted all previous methods of treatment. In order to study the effects of this radioisotope and to prescribe accurate doses for treatment, a method is required to measure the strength of the sources. This is most conveniently done by counting the beta rays emitted, per second, from the preparation of phosphorus. Previous attempts to do this have resulted in errors as large as 300 percent.

The improved method, described in the August Journal of Research (RP1731), consists of a simple geometrical arrangement of a Geiger-Müller counter and source. From the dimensions of this arrangement can be determined the fraction of the total number of beta rays recorded. A simple computation then gives the total number of beta rays for any source for which the beta rays can be counted.

The accuracy of the results obtained in this way has been checked by independent measurements. From these measurements it was found that the absolute errors were much less than 5 percent for phosphorus preparations. This accuracy is entirely adequate for the measurement of medicinal preparations of this radioisotope.

Chemical Treatment Increases Fire Resistance of Wood

Chemically treated lumber has a marked increase in resistance to failure under fire, the improvement ranging from 17 to 33 percent in time over untreated lumber, according to tests by the Bureau. The treatment consists of impregnation with solutions of ammonium salts, borax, and boric acid. In fire-tube tests, the treated wood lost an average of 40 percent of its weight, whereas the untreated wood lost 30 percent.

Eight solid walls of select grade Douglas fir lumber were subjected to the fire endurance tests, four loaded and four unloaded. The chemical treatment added 17 to 23 percent to the failure time of treated walls under load in contrast to the untreated walls. For the walls tested without load, the treatment increased the failure time from 29 to 33 percent.

The added expense of chemical treatment, which may as much as double the cost of the lumber, tends to limit its use to applications where there is a special fire hazard. The walls tested were of a heavy construction, such as might be used as partitions in warehouses.

Four of the walls were made of 2-by-4 inch lumber and four of 2-by-6 inch; half of each group was treated and half untreated. Walls 10 feet square were made for the unloaded test by nailing the pieces together flatwise in horizontal position with 16 or 20d common wire nails, spaced about one foot apart and staggered from side to side. The specimens subjected to load test—8 by 10 feet—were assembled similarly, but were tested with the pieces in vertical position. The results of the tests are summarized in the following table:

Results of fire endurance tests of solid wood walls

Size of lumber	Treatment	How placed	Load lb/in.²	Failure	
				Kind	Time
					hr:min
2 by 4 in	Untreated	Vertically	350	Load	0:46
				Glow on surface	0:46
2 by 4 in	Treated	do	350	Load	0:54
				Glow in waste	1:25
2 by 6 in	Untreated	do	700	Load	1:08
				Glow in waste	1:46
2 by 6 in	Treated	do	684	Load	1:24
				Glow on surface	2:54
2 by 4 in	Untreated	Horizontally	None	Glow in waste	1:25
2 by 4 in	Treated	do	None	Glow on surface	1:53
2 by 6 in	Untreated	do	None	Glow in waste	2:06
2 by 6 in	Treated	do	None	Glow on surface	2:43

New Commercial Standard Provides Uniform Methods for Testing and Reporting Mineral Wool

Uniform procedures for testing and reporting the physical and chemical properties of mineral wool products are provided in Commercial Standard CS131–46, recently announced by the Bureau's Division of Trade

Standards. Through methods which require standard equipment for measuring a particular property, resulting data are placed on a comparable basis and can be reproduced in any laboratory.

Greater uniformity in the testing and reporting of mineral wool products is desirable in order to eliminate confusion resulting from a diversity of test procedures. Originally proposed by the Industrial Mineral Wool Institute, this voluntary commercial standard was developed in cooperation with the entire industry, and brings together for the first time methods accepted on an industry-wide basis. It serves also as an impartial source of information for the use of technical organizations and laboratories concerned with the testing and preparation of specifications for industrial mineral wool products.

The 40 page pamphlet contains methods of testing and reporting the physical and chemical properties of mineral wool products made from rock, slag, or glass. It also describes the equipment required to produce standard results which can be compared and reproduced at any laboratory. Methods of test are included for adhesive strength, compressive strength, corrosion resistance, coverage, density, fire resistance, moisture adsorption, odor emission, shot content, temperature stability, and thermal conductivity. Combinations of test methods may be used to measure qualities familiar to the producer, distributor, and user, that are not specifically designated by name.

The booklet includes a brief history of the project, a list of the official acceptors, and membership of the standing committee, the chief function of which will be to consider revisions of the standard to keep it abreast of progress made in the testing field.

Printed copies of CS131–46 may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at 10 cents each.

Heats, Equilibrium Constants, And Free Energies of Formation of the Alkylbenzenes through C_9H_{12} and of the Higher Normal Monoalkylbenzenes

A report on the chemical thermodynamic properties of the alkylbenzene hydrocarbons, prepared as part of the work of the American Petroleum Institute Research Project 44 and the Thermochemical Laboratory at the Bureau, is presented in the August Journal of Research (RP1732) by William J. Taylor, Donald D. Wagman, Mary A. Greaney, Kenneth S. Pitzer, and Frederick D. Rossini.

For benzene, toluene, ethylbenzene, the three xylenes, normal propyl- and isopropylbenzene, the three methylethylbenzenes, the three trimethylbenzenes, and the higher normal alkyl benzenes, values are presented for the following thermodynamic properties for the gaseous state to 1,500° K: The heat-content function, $(H°-H°_0)/T$; the free-energy function, $(F°-H°_0)/T$; the entropy, $S°$; the heat content, $H°-H°_0$; the heat capacity, $Cp°$; the heat of formation from the elements, $\Delta Hf°$; the free energy of formation from the elements, $\Delta Ff°$; and the logarithm of the equilibrium constant of formation from the elements, $\log_{10}Kf$.

Equilibrium constants and concentrations are given in tabular and graphical form for the isomerization of the four C_8H_{10} alkylbenzenes and for the eight C_9H_{12} alkylbenzenes as a function of the temperature to 1,500° K. Equilibrium constants are also given in tabular and graphical form for some reactions involving alkylation (addition of olefin to benzene to form alkylbenzene), cyclization (conversion of paraffin to alkylbenzenes plus hydrogen), and trimerization (of acetylene to form benzene and of methylacetylene to form 1,3,5-trimethylbenzene).

Spectrographic Standard Samples of Aluminum Alloys

Four spectrographic standard samples of aluminum alloys are now available from the Bureau. The standards, prepared with the cooperation of the Aluminum Company of America, are in the form of disks 2½ in. in diameter and ¾ in. thick. The identifications and compositions of the alloys are as follows:

Number	Kind	Cu	Mg	Si	Fe	Mn	Ni	Cr	Ti	Zn
		%	%	%	%	%	%	%	%	%
601	Wrought alloy 148	4.38	0.39	0.88	0.52	0.81	----	0.020	0.015	----
602	Wrought alloy 248	4.44	1.49	.130	.28	.63	----	.007	.012	----
603	Wrought alloy 618	0.29	1.01	.52	.21	----	----	.24	.037	----
604	Casting alloy 142	3.98	1.56	.27	.45	----	2.00	----	.109	0.029

The standards may be obtained from the Bureau at a price of $8.00 per specimen.

Rate-of-Rainfall Indicator

A rate-of-rainfall indicator has been proposed in which rain is collected in a wide-mouthed receiver, such as is commonly used, and then drains into a connected, adjoining vertical tube. The water runs out of the tube through a capillary tube or orifice. In either case, the head of water above the opening provides a measure of the rate of rainfall. With the capillary tube, the head is proportional to the rate of rainfall, but errors are introduced because of variation in the viscosity of water with temperature. With an orifice, the head is no longer proportional to the rate of rainfall, but the effect of temperature is eliminated.

An experimental model was constructed in which the bore and length of the capillary and the diameter of the receiver were selected to measure rates of rainfall up to 10 inches per hour. Tests showed the indication to be proportional to the rate of rainfall.

The device is inexpensive but requires an observer. However, there would be no difficulty in adding a floating telltale to indicate maximum rates, or in attaching a recording drum, if a continuous record is desired.

Tests of Eppley Pyrheliometers For United States Weather Bureau

Tests have been completed recently by the Radiometry Section on two Eppley pyrheliometers used by the Weather Bureau to measure total solar and sky radiation. The instruments were of modified design with built-in thermocouples to measure the temperature in the vicinity of the receivers. The main purpose of the investigation was to determine the effect of the temperature of the surrounding atmosphere on the instruments in the range between $-40°$ and $+50°$ C. Results obtained are as follows: (1) Efficiencies of the instruments decrease approximately 0.1 percent per 1 degree C rise in ambient temperature; (2) the cosine response is excellent; that is, the response varies with angle of incident radiation in the expected manner; (3) the calibrations of the instruments made by comparison with the Bureau's standard pyrheliometer are in good agreement with those obtained by use of a standard lamp.

Commercial Standard for Hospital Blankets

The large number of types, weights, and qualities of blankets on the market, and the difficulties experienced in purchasing blankets for hospital use, prompted an investigation of that commodity by a subcommittee on blankets of the American Hospital Association. The results of the investigation indicated the desirability of establishing standard quality specifications for blankets for this purpose. The committee therefore requested the cooperation of the Bureau in the development of a commercial standard to cover physical requirements and performance characteristics of those types required for hospital use.

The standard, which includes recommendations submitted by representative wool blanket manufacturers, has been approved by a satisfactory majority of the trade and has been promulgated as Commercial Standard CS136–46. Its requirements are effective for new production from August 30, 1946.

The standard provides for three types of wool and part wool blankets—namely, all wool; 75 percent wool (cotton warp, wool filling); and 50 percent wool (cotton warp, wool and cotton filling). It sets forth minimum requirements for each type, covering size, weight per square yard, thickness, breaking strength, compressibility, colorfastness, shrinkage, and launderability. It also includes methods of test, and the recommended wording by which manufacturers and distributors may guarantee compliance with the standard.

New and Revised Publications Issued During July 1946

Journal of Research [1]

Journal of Research of the National Bureau of Standards, volume 36, number 5, May 1946 (RP1712 to RP1717, inclusive). Price 30 cents. Annual subscription, 12 issues, $3.50.

Title page, corrections, and contents for volume 35, Journal of Research, July to December 1945 (RP1660 to RP1687, inclusive). Price 5 cents.

Commercial Standards [1]

CS129–46. Materials for safety wearing apparel. Price 5 cents.
CS132–46. Hardware cloth. Price 5 cents.

Simplified Practice Recommendations [1]

R183–46. Brass or bronze valves (Gate, globe, angle, and check). Price 5 cents.
R219–46. Automatic regulating valves. Price 5 cents.
R220–46. Open-end and box wrenches. Price 5 cents.
R221–46. Steel rivets (Stock production sizes). Price 5 cents.
R222–46. Hot-rolled carbon steel bars and bar-size shapes (Produced from billets or blooms). Price 10 cents.

Research Papers [1]

RP1700. Spectrophotometric and colorimetric determination of the colors of the TCCA standard color cards. Price 15 cents.
RP1701. Wearing quality of experimental currency-type papers. Price 10 cents.
RP1702. Heats of formation, hydrogenation, and combustion of the monoolefin hydrocarbons through the hexenes, and of the higher 1-alkenes, in the gaseous state at 25° C. Price 5 cents.
RP1703. Studies of binary and ternary combinations of magnesia, calcia, baria, beryllia, alumina, thoria and zirconia in relation to their use as porcelains. Price 15 cents.

Basic Radio Propagation Predictions [1]

CPRL–D23, Basic radio propagation predictions for October 1946 three months in advance. Issued July 1946. Price 15 cents. Annual subscription, 12 issues, $1.50.

Technical News Bulletin [1]

Technical News Bulletin 351, July 1946. Price 5 cents. Annual subscription, 50 cents.

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